

IV. "On the Relation of the Reptiliferous Sandstone of Elgin to the Upper Old Red Sandstone." By Professor JOHN W. JUDD, F.R.S., Sec. G.S. Received November 19, 1885.

The question of the geological age of the yellow sandstones of the district lying to the north of the city of Elgin has been, as is well known, the subject of very animated discussions among geologists. Some have even gone so far as to assert that the evidence on the question, which has been adduced by palæontologists, is absolutely incapable of reconciliation with that relied upon by stratigraphists.

Until the discovery of fossils in the beds in question, it was quite natural to suppose that these white and yellow sandstones, which locally assume reddish tints, are part and parcel of the Upper Old Red Sandstone—a formation presenting somewhat similar mineral characters, and covering a considerable area in the district. This was the view which was taken by Murchison and Sedgwick, Dr. Malcolmson, Dr. Gordon, Mr. A. Robertson of Inverugie, Captain Brickenden, Mr. Patrick Duff, Mr. Martin, and indeed of all the geologists who at first studied the relations of the rocks in Morayshire.

But when fossils, which proved to be of great interest and importance both to the geologist and the biologist, were detected in this formation, a careful re-examination of the evidence relied upon by these geological pioneers was called for. The nature of these remarkable fossils was indeed calculated to awaken the gravest doubt as to the correctness of the commonly received opinions concerning the position in the geological series of the strata which yielded them.

In 1844 Mr. Patrick Duff obtained from the quarries at Lossiemouth, near Elgin, a cast of portion of the dermal covering of an organism of considerable size. Drawings of this fossil were sent by Mr. A. Robertson, of Inverugie, to Agassiz, and were by that naturalist described under the name of *Stagonolepis Robertsoni*.\* Agassiz regarded the fossil as the impression of the scales of a ganoid fish allied to *Megalichthys* and *Glyptopomus*. Six years later, in 1850, Captain Brickenden obtained, from quarries in the same rock, at Cummings-town, a series of remarkable footprints, which were believed by most palæontologists to indicate the existence of reptiles at the time when the beds were deposited; and in the following year Mr. Patrick Duff obtained from the Spynie quarries the skeleton of a small Lacertilian, which was described by Mantell under the name of *Telerpeton Elginense*.† Shortly after this, many more footprints were detected

\* "Monographie des Poissons Fossiles du Vieux Grès Rouge, &c." (1844-5), p. 139.

† "Quart. Journ. Geol. Soc.," vol. viii (1852), p. 97.

in the quarries about Cummingstown and Hopeman, and casts of the dermal armour of *Stagonolepis* were obtained from Findrassie, a little to the south-west of Spynie.

In 1858, Professor Huxley made the important announcement that *Stagonolepis* was not a fish, as supposed by Agassiz, but a Crocodilian; at the same time stating that he had recognized the remains of a third species of reptile among fossils sent to him by Dr. Gordon from Lossiemouth; this new reptile subsequently received the name of *Hyperodapedon Gordoni*.\*

In 1867 the same author was able to demonstrate from fresh and better preserved specimens which had been discovered at Lossiemouth, that *Telerpeton* was not only a true Lizard, but one of a very specialised type;† and two years later he gave a full description of the structure and zoological position of *Hyperodapedon*, showing it to have been a Lacertilian having affinities with the recent *Sphenodon* and the Triassic *Rhynchosaurus*; he was also able to announce the discovery of remains of the same genus in the Keuper of Warwickshire and Devonshire, and in the Maledi (Trias) beds of India.‡

The year 1877 was marked by the publication of Professor Huxley's Monograph on *Stagonolepis*, in which he referred to an interesting cast of a jaw from the Findrassie quarry, to which he gave the name of *Dasygnathus longidens*. This rather obscure fossil, it was shown, might possibly be referable to the fishes or Labyrinthodonts, though it presents some points of resemblance with the Dinosaurs.§

In the year 1884 I saw in the Elgin Museum the cast of a skeleton which had recently been obtained from a quarry newly opened near Elgin, and to be more particularly referred to in the sequel. This fossil appeared to me to be so different from all the remains hitherto found in the formation, that I obtained an impression of it and submitted it to Professor Huxley, who recognised in it certain characters distinctive of the Dinosauria. From the same quarry a skeleton apparently belonging to another lizard, distinct alike from *Telerpeton* and *Hyperodapedon*, with portions of the skeleton of the last-mentioned genus, were also obtained.

Returning to Elgin in the autumn of the present year, I was told by my friend Dr. Gordon that another reptilian specimen, including the skull and some other parts of the skeleton, had been found in the same quarry. On examining this specimen I at once saw that it exhibited the characteristic features of *Dicynodon*, and my opinion on the subject was confirmed by my friend Dr. Traquair, F.R.S., of

\* "Quart. Journ. Geol. Soc.," vol. xv (1859), p. 440.

† *Ibid.*, vol. xxiii (1867), p. 77.

‡ *Ibid.*, vol. xxv (1869), p. 138.

§ "Memoirs of the Geological Survey of the United Kingdom," Monograph III (1877).

Edinburgh, who, at my request, proceeded to examine the specimen. A second example of the same genus has since been discovered, and I trust that ere long a full description of this interesting addition to our British fossils will be given by Dr. Traquair.

In addition to these facts, I may add that casts of teeth, undistinguishable from those of *Ceratodus*, were some time ago obtained from the Spynie quarries.

The present state of the palæontological evidence concerning the age of the beds then is as follows. The strata have yielded the remains of no less than *four orders* of reptiles, all of them belonging to forms very different to any which have been found in Palæozoic rocks. The Lacertilia are represented by *Telerpeton*, *Hyperodapedon*, and an undescribed form; Crocodilia by *Stagonolepis*; Dinosauria by an undescribed skeleton and possibly by *Dasygnathus*; and Dicynodontia by two individuals belonging to the type genus of the order. In addition to these we have a great number of footprints differing so greatly in form and size that they must probably have been made by creatures of very different proportions and organisation. Professor Huxley in his later researches on the subjects of these footprints\* points out the necessity of the greatest caution in any attempts to correlate them with either of the reptiles whose skeletons have been found in the same formation; indeed, he hesitates as to whether the most perfectly preserved of them should be referred to Amphibians or to representatives of one or other of the orders of Reptilia. Among the less perfect of the markings in these and other rocks of the Elgin district, there are not a few concerning which I have serious doubts whether they are to be ascribed to vertebrate animals at all.

It will be seen from this summary that the palæontological evidence in favour of the Triassic age of the Elgin sandstones is now absolutely overwhelming. Besides the remains of *Hyperodapedon* and *Dicynodon*, genera which appear to be confined to Triassic strata, in districts so widely separated as South Africa, India, the Ural Mountains, and the British Islands, we have *Stagonolepis*, a crocodile with Mesozoic affinities, the highly organised *Telerpeton*, and Dinosaurs; the last mentioned having never been found in any rocks older than Trias. *Ceratodus*, too, has usually been regarded as having commenced in the Trias, though it must be admitted that difficulty may exist in separating the cast found at Spynie from *Ctenodus*, which occurs in the Carboniferous, or *Dipterus*, which occurs in the Devonian.

There are certain facts concerning the distribution of these fossils in the formation where they occur, to which it may be instructive to refer as bringing out into strong relief the imperfection of the geological record. The footprints, which are so abundant at Cummingstown and Hopeman, would appear to have been seldom, if ever,

\* "Mem. Geol. Survey," Monograph III, pp. 45-51.

found in the quarries where the bones and scutes occur. All the specimens of these bones and scutes which have been obtained at Lossiemouth seem to have occurred in a single course of rock at the bottom of the quarries, where the useful building stone ceases. All the specimens obtained from this locality seem to belong to *Stagonolepis*, *Hyperodapedon*, and *Telerpeton*. In the new quarry near Elgin, however, neither *Stagonolepis* nor *Telerpeton* has been found, but Dinosaurs and Dicynodonts occur.

Let us now inquire what is the nature of the stratigraphical evidence which has been regarded as opposed to the palæontological arguments in favour of the Triassic age of this formation. At the outset it is necessary to bear in mind two very important circumstances. *First*. The exposures of the Reptiliferous Sandstone and of the Upper Old Red in the district are more or less isolated, the greater part of the country being thickly covered by drift and other superficial deposits. *Secondly*. The whole of the rocks in the district exhibit evidence of having undergone great disturbance; this is shown by their steep inclinations, and by the foldings and fractures which can often be recognised in the quarries opened in them.

The Reptiliferous Sandstone makes its appearance at the surface in two parallel ridges, ranging from north-east to south-west for a distance of about nine miles. The most northerly of these ridges extends from Brandenburgh to Burghead. Although the rocks are well exhibited both in sea-cliffs and in reefs on the shore, the only fossils obtained from them are the footprints of the Cummingstown and Hopenman quarries, near the south-western extremity of the ridge, and the remains of *Stagonolepis*, *Telerpeton*, and *Hyperodapedon*, found in a single bed at Lossiemouth, at its north-eastern end. A tract of about three miles wide, thickly covered by superficial deposits, completely isolates the northern or coast ridge from the southern one, which is known as the Quarrywood ridge. In this Quarrywood ridge the Reptiliferous Sandstone is only found along its northern face for a distance of about three miles. The southern slope of the ridge is composed of the ordinary rocks of the Upper Old Red Sandstone, containing *Holoptychius nobilissimus* Ag., with species of *Glyptopomus* and *Pterichthys*. There is no evidence of the occurrence of Triassic strata, either along the southern slopes of the Quarrywood ridge or in the district lying still further south about the city of Elgin. The localities in which the sandstone containing reptiles has been found along the northern slope of the Quarrywood ridge are as follows:—At Spynie, which may be regarded as a north-eastern prolongation of the Quarrywood ridge, the deep quarries have yielded *Telerpeton*, *Hyperodapedon*, and *Ceratodus*. At Findrassie Wood, a mile and a half further to the south-west, a quarry now abandoned, has yielded *Stagonolepis* and *Dasygnathus*. Lastly, the quarry near the top of the ridge, above

New Spynie Church, and a mile and a half still further to the south-west than Findrassie, has yielded *Hyperodapedon* and another lizard with a Dinosaur and a Dicynodont.

The difference in mineral characters between the Triassic Sandstone on the northern side of the Quarrywood ridge and the Upper Old Red Sandstone on its southern face is certainly not a very striking or well-marked one. But this is a circumstance at which no geologist who is in the habit of studying the Old and the New Red Sandstone will be surprised. Nevertheless, a careful study of the two sets of rocks shows that there are appreciable differences between them, and, as a matter of fact, practised observers like Dr. Gordon seldom find any real difficulty in pronouncing at a glance whether any particular mass of building-stone belongs to the "reptiliferous" or the "holoptychian" formation. It must be admitted, however, that occasionally the pale-pink Old-Red rock assumes a nearly white colour, while the white or yellow "reptiliferous" rocks locally acquire reddish tints, undistinguishable from those of the "holoptychian" sandstone.

In both the coast ridge and the Quarrywood ridge, as was well pointed out by Dr. Gordon, the Reptiliferous Sandstone is seen to be covered by a very peculiar and easily-recognisable deposit, known as the "Cherty rock of Stotfield." It has been frequently suggested that the preservation of these two sandstone ridges, and thus of the whole peninsula between Burghead Bay and Spey Bay, was in all probability due to the presence of this remarkable rock, which offers such resistance to the ordinary agents of denudation.\* The rock consists of a more or less intimate admixture of siliceous and calcareous materials, including also crystallised patches of galena, blende, and pyrites; it has yielded no trace of organic remains. Sir Roderick Murchison compared the "Cherty rock of Stotfield" with the Cornstones of the Old-Red rocks, with which, however, it has but little in common; and some confusion appears to have arisen from bands of true Cornstone, which occur in Upper Old Red Sandstone to the south of Elgin, having been taken for the Cherty rock of the Trias.

Professor Harkness, in 1864, was able to show that the positions in which the Cherty rock and the Reptiliferous Sandstone occur in the neighbourhood of Elgin are such as can only be explained by the existence of great faults. At a later date, I showed how numerous are the indications of disturbance in the district—evidence of tilting of the beds, of actual contortion, and of fracture occurring in many of the quarries. In the New Bishopmill Quarries, for example, the effects of a fault, in throwing side by side beds of valuable freestone and other sandstones unsuitable for building purposes, is very clearly seen, and similar evidence is found all over the area where these beds occur. On the north of the coast-ridge I have shown that beds of

\* "Quart. Journ. Geol. Soc.," vol. xx (1864), p. 424.

Inferior Oolite are seen faulted against the Trias of Stotfield,\* and the same is probably the case also at Burghead. In the great "Scars" or reefs which lie off this coast red sandstones are seen, and I have been assured that scales of *Holoptychius* occur in them. If this be true, then the whole of the Mesozoic strata, forming the peninsula between Burghead Bay and Spey Bay, consists of rocks which are actually let down by trough-faults and synclinal folds into the midst of a tract of the Upper Old Red Sandstone. The presence of such great lines of dislocation is unquestionable, and in the paper referred to I have endeavoured by means of dotted lines to indicate the approximate position of some of them. It must be remembered, however, that in a country so deeply covered by drift as Northern Morayshire, the working out of the relations of the rock-masses by tracing their outcrops at the surface is an almost hopeless task.

As throwing an entirely new light on the age and relations of the Reptiliferous Sandstone of Elgin, I was able in the year 1873 to show that strata identical in character with that deposit and with the Cherty rock of Stotfield occur on the northern, as well as on the southern side of the Moray Firth. At Dunrobin, in Sutherland, the yellow sandstones are seen covered by the Cherty rock, and this in turn is overlain in apparently conformable sequence by the various members of the Lias and Oolite. The whole of the Mesozoic strata of Sutherland are seen to be thrown by a great fault against the Lower Old Red Sandstone and the Crystalline rocks of the Highlands.

Although it is certain, however, that some of the cases of juxtaposition between the Old Red and the Triassic strata must be due to faulting, yet there are reasons for believing that the latter strata lie directly and unconformably upon the former. But, as was remarked by Dr. Gordon in 1877, "the district is so covered by drift that no junction of the Holoptychian and the Reptiliferous strata has been laid bare."

It was therefore with the greatest interest that in the summer of 1884 I learned from that veteran geologist, whose important services to science have extended over a period of more than half a century, that the bones of reptiles had at last been detected in the same quarry with the remains of *Holoptychius*. On repairing to Elgin I received the greatest assistance in investigating the matter from Mr. J. Gordon Phillips, the intelligent and energetic curator of the Elgin Museum.

It appears that about the beginning of 1882 an old stone-pit, known as "the Millstone Quarry," and situated near the summit of the Quarrywood ridge, immediately above the church of New Spynie, had been reopened, and extensive excavations had since been carried on there. The beds here present a somewhat similar character to those

\* "Quart. Journ. Geol. Soc.," vol. xxix (1873), p. 128, &c.

of Lossiemouth and Spynie, consisting of white or pale-yellow sandstone, containing occasional black particles composed of iron and manganese oxides. The sandstones of this pit are generally much coarser in grain than those at Lossiemouth and Spynie, and they sometimes even pass into a grit. In some of the beds, particles of felspar occur in such profusion as almost to cause the rock to assume the appearance of an "arkose." That these rocks really belong to the Reptiliferous Sandstone has been confirmed by the finding, up to the present time, of no less than six skeletons of reptiles, and by the total absence from them of the "Old-Red" fish-remains.

The Reptiliferous Sandstone, both of the coast ridge and of the Quarrywood ridge, not unfrequently contains scattered pebbles of quartz; but at the "Cutties' Hillock Quarry," as the new pit is now called, this feature is more strikingly exhibited, and such quartz-pebbles become very abundant, especially in some of the lower beds. As the excavations were carried downwards, indeed, the coarse sandstone was seen passing into a conglomerate, called by the workmen the "pebbly-post." This bed of conglomerate was found to be from 3 feet 6 inches to 4 feet thick, and, it being considered desirable to determine if other courses of freestone fit for building purposes underlie the "pebbly-post," a trial-shaft was opened at the bottom of the quarry.

It was discovered in this way that the "pebbly-post," which in its lower portion becomes more perfectly conglomeratic, and contains pebbles of white and purple quartz up to the size of the fist, rests on beds of pink and red sandstones, very finely laminated, and exhibiting evidence of much false-bedding. These beds are strikingly different in character from the coarse-grained, white sandstones lying above the "pebbly-post," in which the bedding is usually indistinct and imperfect. The stone lying below the conglomerate was found to be unsuited for building purposes, and the trial-shaft, after being carried to the depth of 13 feet in the bottom-rock, was abandoned; very fortunately, however, the last blast which was fired in it revealed a remarkably fine specimen of *Holoptychius*, which has been identified by Dr. Traquair as *H. nobilissimus*, and is now in the Elgin Museum.

It unfortunately happened that no careful geological study was made of the beds exposed in the trial-shaft at the time when it was open; but I was able, with the assistance of Mr. J. Gordon Phillips, and of Mr. Watts, the very intelligent lessee of the quarry, aided by an inspection of the materials thrown out, to substantiate the above facts and to add the following details:—

The red and finely-laminated sandstones of the Upper Old Red Sandstone are directly overlain by the bed of quartzose conglomerate. This latter bed, which is from 3 feet 6 inches to 4 feet in thickness, contains fewer and smaller pebbles in its upper part, and thus

graduates insensibly into the coarse Reptiliferous Sandstone, which forms a number of courses, each from 3 feet to 4 feet thick, and are exposed to a depth of over 20 feet. The Reptiliferous Sandstone in this pit section exhibits evidence of considerable disturbance; its beds dip to the north-east at an angle of about  $15^{\circ}$ , while, at one part of the pit, there are indications, in great slickensided surfaces and a slight displacement of the beds, of a small fault. In these upper sandstones remains of a least six reptiles have up to the present time been discovered, five of them occurring in one course of stone, while the remaining one came from the bed immediately below. The forms represented in this pit are *Hyperodapedon*, and another lizard, *Dicynodon*, and a Dinosaur.

The characters of the sandstones above the bed of conglomerate are very distinct from those of the sandstones below it. The former are very fine grained and have their lamination very strongly pronounced, exhibiting much false-bedding; while the latter are usually much coarser and seldom show any trace of stratification. The colours, too, are very distinctive, but this is a character upon which it would be unwise to place much reliance. Examined in thin sections, under the microscope, I found that the two sandstones present well-marked and constant differences.

These facts all point to the conclusion that the Reptiliferous Sandstone of Elgin passes downwards into a bed of conglomerate, which rests unconformably upon the strata of the Upper Old Red Sandstone.

During a visit to Sutherland last year, I also obtained evidence that a precisely similar relation in all probability exists between the Triassic rocks and the Upper Old Red Sandstone on the northern side of the Murray Firth.

Some years ago Dr. Joass of Golspie found remains of *Holoptychius* in the sandstones which crop out in reefs on the shore at some distance southward from that place. Between these reefs of Upper Old Red Sandstone and those of Dunrobin, where I was able in 1873 to identify the Reptiliferous Sandstone and the Cherty rock overlying it, the rocks are wholly concealed. But Dr. Joass showed me masses of a conglomerate which are frequently thrown up by the waves on the Golspie shore, containing yellow and purple quartz-pebbles, and identical in character with the rock of the "pebbly-post" in the Cutties, Hillock Quarry near Elgin. There can be little doubt that the bed from which these fragments are derived lies between the Trias and the Upper Old Red Sandstone of the Sutherland coast.

The Royal Society long ago testified its sense of the importance of determining the age and relations of the remarkable strata of Elgin, by appointing a Committee and making a grant from the Donation Fund to aid in securing new specimens of the fossils. Seeing, then, that an opportunity offered itself for determining the exact relations

of the Reptiliferous to the Holoptychian beds, I preferred a request to the Council of this Society for a grant to be applied in excavations directed to uncovering the line of junction between the two beds.

My request having been acceded to, the kind intervention of Dr. Gordon obtained for me the permission of Thomas Yool, Esq., of Leuchars, the factor of the Earl of Fife, on whose property the quarry is situated, for carrying out the necessary work. The Messrs. A. and W. Watt, the lessees of the quarry, not only rendered much valuable advice and assistance, but kindly undertook the personal superintendence of the necessary operations. In making a careful examination of the pit, after it had been opened, I had the great advantage of the aid and judicious counsel of Professor T. G. Bonney, F.R.S., President of the Geological Society.

We were able to observe that, while the conglomerate of the "pebbly-post" graduates insensibly into the overlying Reptiliferous Sandstone, it is sharply divided from the red sandstones below. It was unfortunately found that, owing to the imperfect bedding of the upper series and the prevalence of oblique lamination in the lower one, it was impossible to obtain decisive evidence of a discordance of dip between them. But the line of junction between the two sets of strata, which was exposed for a distance of 10 feet only, showed every appearance of being an eroded one. We came to the conclusion that while the upper series having the "pebbly-post" for its base, is certainly perfectly distinct from the lower one, there can scarcely be the smallest doubt that the former rests unconformably upon the latter; in other words, the evidence points to the conclusion that during the vast periods of the Carbiniferous and Permian, the Upper Old Red Sandstone of the Elgin area was upheaved and denuded, and that subsequently the Upper Trias beds were deposited unconformably upon the eroded surface.

As the question of the age and relations of these interesting rocks may now be considered as definitely settled, it may be well to give a brief *résumé* of what is known concerning the interesting patches of Triassic strata in the east of Scotland, from which such important palæontological treasures have been derived.

There is reason for believing that the Trias of this district does not exceed 200 to 300 feet in thickness. At present it is known to occur only in the coast ridge, 9 miles long and about 1 mile broad, and on the northern slope of the Quarrywood ridge for a distance of about 3 miles. Outlying patches, like the Boar Rock in Spey Bay, show that its superficial extent has been greatly reduced by denudation and the deposit of drift upon it. Similar beds covering only a very small area however, make their appearance on the northern side of the Moray Firth, between Dunrobin and Golspie.

The lowest member of the formation consists of quartzose con-

glomerate, very similar to that which occurs in the Poikilitic of the west coast of Scotland, and of many parts of England. This, by the gradual diminution in the size and number of the pebbles, passes occasionally up insensibly into a coarse grit, containing scattered quartz pebbles, and, finally, into the very fine-grained white or yellow sandstone which constitutes the bulk of the formation.

In the whole of this deposit, organic remains are very sparsely distributed. The extensive sea-cliffs and shore-reefs of the coast ridge have not yielded a single specimen, nor have any fossils been found in similar situations in Sutherland. Many of the largely worked quarries have proved equally barren. Several quarries in immediate proximity to one another have, however, yielded footprints, and a single band of soft rock in the Lossiemouth Quarries, situated at the depth of about 100 feet from the top of the sandstone series, has yielded many remains of *Stagonolepis*, *Hyperodapedon*, and *Telerpeton*. It is not improbable that it is a bed on about the same horizon which has yielded *Telerpeton*, *Hyperodapedon*, and *Ceratodus* at Spynie, and *Stagonolepis* and *Dasygnathus* at Findrassie. The new quarry at Cutties' Hillock, however, is certainly opened in beds *lower* in the series, and, indeed, near its base. The only form up to the present found in this lower division which is common to it and the higher strata is *Hyperodapedon*, but the lower beds have also yielded a Dinosaur, a Dicynodont, and a new species of Lacertian. There are good grounds for anticipating further important discoveries in this part of the series, as large quantities of stone are now being taken from the quarry in which it is exposed.

The beds of the Reptiliferous Sandstone are often seen to be traversed vertically by masses of a hard quartzite-like rock, which are known to the quarrymen as "keys." Such masses are seen rising through the sandstones in the sea-cliffs, and in many of the quarries, where, being unfit for building purposes, they are either avoided in the quarrying operations, or are broken up to serve as road-metal. A key of this kind is present in the quarry at Cutties' Hillock. Microscopic examination of these quartzite-like masses shows them to consist of the ordinary white or yellow sandstone, in which silica has been deposited in the form of quartz upon and between the individual grains. As in the case of the "crystallised sandstones," and many quartzites, the secondary silica is in crystallographic continuity with the quartz grains on which it is deposited; this is clearly shown when thin sections of the rock are examined by polarised light, the orientations of the original and the secondary quartz, as exhibited by their optical characters, being thereby rendered manifest.

Overlying the Reptiliferous Sandstone is the very remarkable calcareous and siliceous rock, known as the "Cherty rock of Stotfield," the peculiar characters of which have been already indicated. At

present this member of the series is only seen as a number of isolated patches, and we have no evidence as to whether it ever constituted a continuous deposit. Its thickness is never great, and probably in no case exceeds 30 feet.

The "Cherty rock of Stotfield" which has afforded no traces of organic remains, even when studied under the microscope, is evidently a chemical and not an organic deposit. Its appearance and characters, indeed, strongly suggested that, like very similar deposits in Hungary, it may have been formed by geysers, an idea which was entertained by Sir Charles Lyell. If this be so, it is impossible to avoid entertaining the suggestion that the formation of the keys may have been due to the rise of heated water containing silica in solution along the joint planes of sandstones below. Some support is afforded to this suggestion by the fact that where, as at Stotfield, the Cherty rock is largely developed, there the quartzite "keys" are particularly numerous in the underlying sandstones.

It may be of some interest to add that the Trias of the district of Scania in Southern Sweden contains rocks quite undistinguishable in their mineral characters from the Pebbly Conglomerate, the Reptiliferous Sandstone, and the Cherty rock of the Trias of Eastern Scotland.

V. "Experimental Researches in Cerebral Physiology. II. On the Muscular Contractions which are evoked by Excitation of the Motor Tract." By V. A. HORSLEY, M.B., B.S., Professor Superintendent of the Brown Institution and Assistant Professor of Pathology in University College, London, and E. A. SCHÄFER, F.R.S., Jodrell Professor of Physiology in University College. Received December 1, 1885.

The following note gives the results of a large number of experiments which we have undertaken, in order to determine the character of the muscular contractions which result from excitation of the several parts of the motor tract, especially with reference to the rhythm with which the skeletal muscles respond to such excitation.

For the purpose of our experiments we may consider the motor tract under four heads, viz.:—1. Its commencement in the nerve-cells of the cerebral cortex. 2. The connexion of these cells with the lower nerve-centres by the nerve-fibres in the corona radiata. 3. Its continuation along the medulla oblongata and medulla spinalis (including the nerve-cells of those structures). 4. Its peripheral continuation along the motor nerves.